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INTERIM FINAL POLICY AND GUIDANCE ON RISK ASSESSMENTS FOR CORRECTIVE ACTION AT RCRA FACILITIES

The attached interim final policy and guidance on risk assessments assures hazardous waste program consistency between closure requirements, corrective action requirements, and other program requirements that involve risk evaluations This policy represents the currently applied risk evaluation methodology used by the Hazardous Waste Control Program of the Hazardous Materials and Waste Management Division

The policy and guidance is being distributed as an "interim final" document The Division invites comments and/or questions concerning this document These should be sent to

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Hazardous Materials and Waste Management Division
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Following a comment period, which will conclude on June 30, 1994, the policy will be updated and finalized

original signed by — 16 Nov '93
Joan Sowinski, Program Manager — Date
Hazardous Waste Control Program
Hazardous Materials and Waste Management Division

Note: This document has been reformatted to make it more accessible in Portable Document Format (PDF). No other changes were made.

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INTERIM FINAL POLICY AND GUIDANCE ON RISK ASSESSMENTS FOR CORRECTIVE ACTION AT RCRA FACILITIES

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GLOSSARY

Background Levels - defined as the arithmetic mean plus two standard deviations for the data set consisting of samples from unaffected or upgradient areas of the facility

CDH- Colorado Department of Health (now Colorado Department of Public Health and Environment)

CHWA - Colorado Hazardous Waste Act

CHWR - Colorado Hazardous Waste Regulations

CMS - Corrective Measures Study A study, undertaken by the facility, to evaluate appropriate remedial alternatives available for the SWMU or release site, given the physical characteristics and chemical constituents present at the site The CMS includes, at a minimum, an evaluation of the protectiveness, short and long term effectiveness and reliability, implementability, cost, and community acceptance associated with each remedial alternative

Detection limits - an appropriate detection limit must be used in the analytical program These detection limits can be found in SW 846, 2nd Edition (available from the Division) Appropriate detection limits include the "estimated quantitation limits" specified in the method description, unless other limits are agreed upon by the Division In the case of multiple potentially appropriate detection limits, consult the Division

Soil - as used in this document, "soil" includes surface soils, subsurface soils to a depth of 12 feet (basement foundation excavation depth), and sediments Sediments are soils associated with, and possibly deposited or reworked by, water, e g stream or lake sediments Contaminated subsurface soils deeper than 12 feet need not be considered in the risk assessment, but will be considered in any subsequent corrective action

SWMU - Solid Waste Management Unit - Any discernible unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste

The Division - the Hazardous Materials and Waste Management Division of CDH

CORRECTIVE ACTION RISK ASSESSMENTS

1.0 STATEMENT OF POLICY AND PURPOSE

This document presents the interim final policy of the Colorado Department of Health, Hazardous Materials and Waste Management Division (the Division), regarding risk assessment methodology and the use thereof in making corrective action decisions at hazardous waste treatment, storage, or disposal (TSD) facilities and hazardous waste generator facilities regulated by the Colorado Hazardous Waste Act (CHWA) and its implementing regulations (CHWR) Corrective action may be required for permitted TSD facilities (CHWR, Section 264 101) and at interim status TSD facilities seeking permits (CHWR, Section 265 5), or at generator facilities where a release of hazardous constituents to the environment has occurred

Protection of human health and the environment is required in each of the above regulatory citations as the standard for corrective action performance To ensure this protection, the Division requires application of the following three-screen approach for evaluating the need for corrective action at any Solid Waste Management Unit (SWMU) or release site on a facility

Screen 1 - The first screen applied to SWMUs or release sites is a comparison to background and/or detection limits A SWMU or release site would move to the second and third screen if any medium affected by a release contains an analytically determined concentration of contaminant[1] that

a) exceeds detection limits (see glossary) for organic compounds except those that are naturally occurring, and/or
b) exceeds background levels (see glossary) for inorganic and naturally occurring organic compounds

SWMUs or release sites that meet the levels prescribed in criteria a) and b) are considered "clean" and further action would not be necessary

Methods to compare contaminant levels in a SWMU or release site to background/detection limit levels (criteria a) and b)) are beyond the scope of this policy (more information on criteria a) and b) is available from the Division) Briefly, however, appropriate detection limits must be used for criterion a) and use of appropriate statistical methods is important for criterion b) In addition, for criterion b), an evaluation of the site-specific data set should be conducted This evaluation should include a spatial and temporal analysis of indicated contamination along with an evaluation of the number of "detects" for each contaminant at the site, data outliers, and data quality

Screen 2 - The second screen applied to a SWMU or release site is a risk evaluation Screen 2 only applies when detection limits and/or background, as described in criteria a) and b) above, are exceeded and the medium is not a characteristic hazardous waste A

[1]For the purposes of this policy, the concentration of contaminants is the total concentration and not the TCLP concentration

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Corrective Measures Study (CMS), or equivalent, to identify appropriate corrective actions will be required if concentrations of contaminants in the SWMU or release site

c) present a risk to human health greater than $1X10^{-6}$, using a risk analysis procedure approved by the Division Director, for carcinogenic compounds, and/or

d) present a Hazard Quotient greater than 1 0 for noncarcinogenic compounds,

Even SWMUs or release sites that do not exceed the risk levels prescribed in criteria c) and d) must move on to Screen 3

Screen 3 - The third screen applied to a SWMU or release site is comparison of contaminant levels to ground water protection criteria It is possible that soil contamination at a site is above background, but below risk thresholds, and could still leach unacceptable levels of contaminants to ground water In this case, a CMS, or equivalent, will be required to identify appropriate mitigation alternatives

<u>Section 1 1</u> The remainder of this guidance and policy presents the methodology for evaluating SWMUs and release sites against criteria c) and d) presented in Screen 2

It is important to note the difference between Risk Assessment, Risk Management, and Corrective Action Risk assessment only evaluates the risk that contamination poses at SWMUs or release sites Risk management through a CMS, in turn, evaluates the management options (corrective actions) for sites with excessive risk Risk Management corrective actions fall into two general categories management of the risk through appropriate controls (institutional, source, etc), or management of the risk via cleanup and/or removal of the media exceeding the unacceptable risk levels The appropriate risk management technique for a given site will be determined after the CMS, or equivalent

It should also be noted that corrective action is not dependent on or triggered only by risk to human health As presented above, environmental protection and protection of ground water resources (from migration or leaching of contaminants) could also be the basis for a corrective action

The risk assessment methodology presented herein is generally consistent with the methodology presented in Risk Assessment Guidance for Superfund or RAGS (EPA, 1989a) However, the Division has determined that an abbreviated version of the RAGS methodology is sufficient to meet our decision making needs The remainder of this policy explains how a facility can perform a risk assessment to evaluate the risk levels described in criteria c) and d) This methodology has been approved by the Division Director

In addition to the policy, this document also provides guidance on the implementation of the policy The policy and guidance are intended for use by Division staff and the staff of facilities that will be making corrective action decisions

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2 0 RISK ASSESSMENT METHODOLOGY

After data is collected from a site to assess the nature and extent of contamination through implementation of a RCRA Facility Investigation (RFI) Workplan or other sampling plan approved by the Division, the facility may assess where contamination exists that exceeds the detection limits or background levels as indicated in criteria a) and b), or may begin a risk assessment If possible, the facility should consider whether cleanup of contaminated areas to criteria a) and b) standards is feasible, desirable, or warranted If cleanup to criteria a) and b) levels will be conducted, no risk assessment is necessary If not, the risk assessment to delineate areas of contamination that exceed risk levels described in criteria c) and d) can begin

The risk assessment is subdivided into three main tasks, as follows

1) Exposure Assessment
2) Toxicity Assessment
3) Risk Characterization

The following sections describe each of these subdivisions of the risk assessment in detail

3 0 EXPOSURE ASSESSMENT

Generally the exposure assessment consists of three steps 1) characterization of the exposure setting, 2) identification of the exposure pathways, and 3) quantification of exposure For corrective action, as is described in Section 3 1, the exposure setting and exposure pathways both must evaluate direct exposure to all contaminated media within, or affected by, a contaminant release Quantification of exposure is covered in Section 3 2

3 1 Exposure Setting and Pathways

At any facility, for corrective action purposes, the risk associated with Section 1 0 criteria c) and d) must be determined

1) assuming certain residential exposure pathways are or will become complete using a residential exposure scenario,
2) using the primary "direct exposure"[2] pathways in the residential exposure scenario,
3) considering children as a sensitive subpopulation for the first six years of the exposure,
4) assuming no dilution or attenuation of contamination to the receptor, and
5) on a SWMU- or release-specific basis

These items are discussed further in the following sections

[2] "Direct exposure" in this policy shall mean placing a receptor (current/future resident or industrial worker) on or in the source - i e , the SWMU or release site

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3 1 1 Residential Exposure

For a corrective action site to be completely released from regulatory control, it is necessary to clean the site to a level that supports unrestricted use To support unrestricted use, the Division requires on-site residential exposure as the bounding scenario It is assumed that if the site is cleaned to levels that do not present an unacceptable risk to on-site residents, then it will not present unacceptable risks for any other human use Therefore, the Division assumes a residential receptor at or within a SWMU or release site and requires that the risk to that receptor be evaluated assuming ingestion, inhalation, and dermal exposure

Long term future use of any site is difficult to predict Therefore, even sites that are currently within a large industrial complex must consider the future on-site residential exposure scenario In these cases, appropriate current and future worker exposure scenarios may also be considered If the site can be cleaned to a level that does not present unacceptable risk to current and future workers, even though it is not clean enough to support unrestricted use, further cleanup of some portions of the facility may be deferred to a time when use changes Depending on the types and amounts of contamination, however, monitoring and stabilization of the site are usually necessary during this cleanup deferral period to assure that contamination does not continue to worsen or spread

3 1 2 Direct Exposure

Within the residential and worker exposure scenarios described above, the hypothetical resident or worker is placed on or within the SWMU boundary or any additional area affected by a release Inhalation, ingestion, and dermal contact are the routes of exposure considered for each contaminant

The list of direct exposure pathways that need to be evaluated is limited to the following

a) ingestion of soil (see glossary),
b) dermal contact with soil,
c) inhalation of soil particles
d) ingestion of homegrown fruits and vegetables, and
e) inhalation of indoor air VOCs

Water-related pathways have not been included The reason for this is presented in Section 3 1 2 1 In addition, pathway d) should not be applied to workers at facilities, or portions thereof Details, including intake calculation equations and exposure parameters for each of these pathways, are provided in Appendix A, Tables A-1 through A-9

3 1 2 1 Water Pathways

For releases of contaminants that consist of , or include, contaminated surface or ground water that exceeds State and/or Federal water quality standards, the Division applies the standards in lieu of an evaluation of the water pathways in the risk assessment In these cases, the contamination in the water above the standard would require corrective action

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The Division applies, for each chemical, the most stringent of the following water quality standards

a) protective Colorado water quality standards as set by the Colorado Water Quality Control Commission including, but not limited to
   - domestic use water supply standards
   - agricultural water supply standards

b) Safe Drinking Water Act standards

c) Clean Water Act standards

Cases where no water quality standards exist for specific contaminants will be handled on a case-by-case and site-specific basis by the Division

3 1 2 2 Soil Pathways

For each area of soil contamination, only certain direct exposure pathways are required to be evaluated and are listed above in Section 3 1 2

It should be noted again that the ultimate corrective action for soil contamination at a facility must take into account not only direct exposure, but also potential future migration to, and protection of, ground water (i e leachability, migration) and other environmental receptors

3 1 3 Sensitive Subpopulations

The Division requires that, for each pathway considered, exposure parameters for children (age 0 to 6), as a common sensitive subpopulation, be included in the evaluation Children are a very common subpopulation with unique toxicological and dose-response parameters The appropriate exposure parameters for children have been included in Appendix A

Other sensitive populations unique to the site in question may also need evaluation This will be determined on a facility-specific basis at the discretion of the Division

3 1 4 Dilution/Attenuation

Because use of the direct exposure route is required, no dilution or attenuation of the contaminant concentrations can be assumed Arguments relying on fate and transport calculations will not be accepted in the exposure assessment (fate and transport are considered in the corrective action decision)

3 1 5 SWMU- or Release-Specific Risk Evaluation

The decision to take a corrective action will be made by the Division for each SWMU or release site individually This is clear in CHWR, Sections 264 101 and 265 5 Therefore, the risk evaluation must also be completed for each SWMU or release site that contains contaminated soil (per section 3 1 2 1 and 3 1 2 2 above)

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To the extent that contaminated sites are adjacent to one another, have similar contamination, and a probable similar remedy, the corrective action may be combined, but the risk evaluation cannot If releases from different SWMUs or sites coalesce or overlie one another such that the risk in the area of dual contamination may be higher than when both SWMUs are considered separately, this additive risk must be considered Alternatively, if a SWMU or release site is sufficiently large and has varying contaminant levels and/or contaminant suites, the site can be subdivided into separate risk evaluations at the discretion of the Division

3 2 Exposure Quantification

In order to calculate risk, it is, first necessary to determine contamination intake of the receptor Intakes are calculated using standard equations (EPA, 1989a) that include parameters for exposure concentration, contact rate, exposure frequency, exposure duration, body weight, and exposure averaging time These equations are pathway-specific and appear in Appendix A For corrective action, direct exposure requires that the exposure concentrations used to calculate intake equal the **maximum** site contaminant concentrations

Intakes are expressed in terms of the mass of contaminant in contact with the body (ingested, inhaled, or dermally exposed) per unit body weight per unit time (mg contaminant/kg body weight-unit time or mg/kg-day)

The values for the variable parameters in the equations have been standardized in Appendix A where possible Some parameters have been assigned default values, but could be adjusted for site-specific conditions by either the facility or the Division Variations from the default values must be approved by the Division

The result of the Exposure Quantification is an estimated intake for each chemical in soil for each pathway An example table shell for exposure quantification is presented in Table A-10 of Appendix A

4.0 TOXICITY ASSESSMENT

The Toxicity Assessment consists of determining the toxicity values for both carcinogenic and non-carcinogenic effects of site contaminants Because toxicity information may change rapidly and quickly become outdated or expanded, care must be taken to find the most recent information

Generally, the two best sources are, in order of preference, the Integrated Risk Information System (IRIS) which is updated monthly and provides verified reference doses (RfDs) and slope factors, and the Health Effects Assessment Summary Tables (HEAST) which provides interim and verified values for RfDs and slope factors HEAST information should be sought only for those chemicals not listed in IRIS

Toxicity information may be found in many additional sources such as other EPA documents, the Agency f or Toxic Substances and Disease Registry (ATSDR),

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medical/technical publications, etc Before using information from references other than IRIS and HEAST, approval of the Division is required

If toxicity information on a chemical is unavailable, the Division should be consulted Generally this occurs because the chemical is not suspected of causing detrimental effects to humans, because the current data is being re-evaluated, or because there is insufficient data to develop RfD and slope factor values The Division will handle these cases individually Depending on the reason for unavailable toxicity information, the Division may accept a qualitative risk evaluation of the chemical

If toxicity information is only available for some, but not all, of the routes of exposure being considered, the Division should consulted Route-to-route extrapolation may be recommended if appropriate, or the contaminant may be considered only in the pathways with information Again, the Division will handle these cases individually and may accept a qualitative evaluation of the affected pathways

The results of the Toxicity Assessment should be RfDs for all non-carcinogenic constituents and slope factors for all carcinogenic constituents collected for each contaminant in each medium and each pathway For example, if a site is contaminated with methylene chloride, an RfD and slope factor for methylene chloride should be determined for ingestion, dermal contact, and inhalation since methylene chloride is both a non-carcinogenic toxicant and a class B2 carcinogen

<u>5 0 RISK CHARACTERIZATION</u>

The final step in the risk assessment process is Risk Characterization This step combines the exposure and toxicity assessments into a risk calculation The risk calculation is different for carcinogens and non-carcinogens

<u>Carcinogens</u> Carcinogenic risk is calculated by multiplying the contaminant intake in one pathway (from the exposure quantification in Section 3 2) by the slope factor for the contaminant in that pathway This is done for each contaminant and pathway These contaminant/pathway specific risks are summed together for a total SWMU- or release-specific risk This is a three step process 1) calculate the risk for each chemical in a given pathway, 2) sum all of the risks for all of the chemicals in that pathway, and 3) perform steps 1) and 2) f or all pathways and sum all of the pathway risks into a total risk The numerical result is the excess probability that an individual will develop cancer because of exposure to the site over a lifetime, given the exposure parameters used in the intake calculation and the contaminants at the site As expressed in Section 1 0, criterion c), any SWMU or release site with a total risk greater than 1×10^{-6} (or 1 added cancer death per million exposed individuals) presents an unacceptable risk to human health and will require a Corrective Measures Study (CMS) , or equivalent, to identify appropriate corrective actions to manage the risk

~~When possible, organ specific carcinogenic risk should be evaluated If the level of risk from the SWMU or release site to any specific organ exceeds $1X10^{-6}$; a CMS, or equivalent, will be required to identify appropriate corrective actions to manage the risk (It should be noted that, when organ-specific risk is evaluated, while the risk to any one~~

~~organ presented by a contaminated site may not exceed $1X10^{-6}$, the total risk from the SWMU or release site could exceed $1X10^{-6}$ Where total organ-specific risk does not exceed $1X10^{-6}$, a CMS would not be required~~

Non-Carcinogens Non-carcinogenic effects are expressed as a ratio of the contaminant intake in one pathway (from the Exposure quantification in Section 3 2) to the RfD for that pathway This ratio is called the Hazard Quotient (HQ) HQs are determined for each contaminant and pathway and then summed together for a total SWMU- or release-specific HQ This is a three step process 1) calculate the HQ for each chemical in a given pathway, 2) sum all of the HQs for all of the chemicals in that pathway, and 3) perform steps 1) and 2) for all pathways and sum all of the pathway HQs into a total HQ As expressed in Section 1 0, criterion d), any SWMU or release site with a total HQ over 1 0 presents an unacceptable risk to human health and will require a CMS, or equivalent, to identify appropriate corrective actions to manage the risk An HQ greater than 1 0 implies that the intake of the contaminant(s) at the site will be greater than the intake that is known to cause detrimental effects to humans

When possible, organ-specific effects should be evaluated If the hazard from a SWMU or release site to any organ exceeds 1 0, a CMS, or equivalent, will be required to identify appropriate corrective actions to manage the risk (As with carcinogens, when organ-specific effects are evaluated, even though the HQ for any organ does not exceed 1 0, the total HQ from the SWMU or release site could exceed 1 0 Sites where organ specific HQ do not exceed 1 0 would not require a CMS)

Example tables for both risk and HQ calculation can be found in Appendix A (Tables A-11 through A-14) ~~Case study examples of exposure quantification and risk characterization can be found in Appendix C~~ This risk assessment procedure lends itself to computer spreadsheet applications The Division is pursuing these and will make them available at the earliest possible time

****** Certain aspects of traditional risk assessments have been omitted from the methodology presented in this policy This includes such items as uncertainty analysis, elimination of essential nutrients, and elimination of an evaluation of water contamination risk This was done to simplify and standardize the risk determination and methodology as well as to alleviate financial burdens on facilities conducting risk assessments Should any facility wish to incorporate portions of the risk assessment that are not included herein, they may do so In particular, these additional risk assessment efforts may be warranted for facilities with risk levels only slightly above the limits presented in Section 5 0 Any such efforts will be considered by the Division, but should be in addition to compliance with the requirements of this policy

Joan Sowinski, Program Manager Date 16 Nov 1993
Hazardous Waste Control Program

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APPENDIX A Exposure Quantification Equations and Parameters

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Table A-1

Exposure Parameters and Intake Algorithm
Residential Exposure: Soil Ingestion

$$\text{Intake (mg/kg-day)} = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

Parameter	Adult	Child
C = Chemical concentration in soil (mg/kg)	Site-specific	Site-specific
IR = Ingestion Rate (mg/day)	100[1]	200[1]
EF = Exposure Frequency (days/year)	350[2]	350[2]
ED = Exposure Duration (years)	24[3]	6[3]
CF = Conversion Factor (kg/mg)	10^{-6}	10^{-6}
BW = Body Weight (kg)	70[4]	15[4]
AT = Averaging Time (days)		
Noncarcinogenic	~~8760~~[5] 10950	~~2190~~[5] 10950
Carcinogenic	25550	25550

(1) EPA 1989a, Exhibit 6-14, EPA 1989b, EPA 1989d, EPA 1991a

(2) EPA 1991a, The value of 350 days/year for exposure frequency assumes that the average person is away from their residence 15 days, or two weeks, each year

(3) EPA 1989a, Chapter 6, 30 years is the national upper bound (90th percentile) for time spent at one residence Since the exposure scenario is broken into children and adults, parameters for children are applied for six years, and parameters for adults applied for 24 years, EPA 1989a

(4) Adults EPA 1989a, Chapter 6, EPA 1989d, Children EPA 1991a

(5) 8760 days = 24 years x 365 days/year
2190 days = 6 years x 365 days/year
25550 days = 70 years x 365 days/year

Table A-2

Exposure Parameters and Intake Algorithm
Residential Exposure. Dermal Contact with Soil

Intake (mg/kg-day) = $\frac{C \times SA \times AB \times AF \times EF \times ED \times CF}{BW \times AT}$		
Parameter	**Adult**	**Child**
C = Chemical concentration in soil (mg/kg)	Site-specific	Site-specific
SA = Exposed Surface Area of body (cm^2)	7100[1]	4600[1]
AB = Absorption Factor (unitless)	0 5[2]	0 5[2]
AF = Adherence Factor (mg/cm^2/event)	1 0	1 0
EF = Exposure Frequency (events/year)	350[3]	350[3]
ED = Exposure Duration (years)	24	6
CF = Conversion Factor (kg/mg)	10^{-6}	10^{-6}
BW = Body Weight (kg)	70	15
AT = Averaging Time (days)		
Noncarcinogenic	~~8760~~ 10950	~~2190~~ 10950
Carcinogenic	25550	25550

(1) For calculation of these numbers, see Appendix B

(2) Absorption is chemical specific Values for some chemicals are available in EPA 1992a In the absence of published data, a value of 0 5 will be used (EPA 1989a, page 6-39)

(3) It is assumed that exposure to indoor dust and outdoor soil occurs 350 days/year It is further assumed that the concentration of contamination in the indoor dust is equal to contaminant levels in the outdoor soil

Table A-3

Exposure Parameters and Intake Algorithm
Residential Exposure: Inhalation of Soil Particulates

Use only for inorganic constituents

$$\text{Intake (mg/kg-day)} = \frac{C \times CF \times IR \times ET \times EF \times ED}{PEF \times BW \times AT}$$

Parameter	Adult	Child
C = Chemical concentration in soil (mg/kg)	Site-specific	Site-specific
CF = Conversion Factor (kg/mg)	10^{-6}	10^{-6}
IR = Inhalation Rate (m^3/hour)	0 83(1)	0 73(1)
ET = Exposure Time (hours/day)	24	24
EF = Exposure Frequency (days/year)	350(2)	350(2)
ED = Exposure Duration (years)	24	6
PEF = Particulate Emission Factor (m^3/mg)	4630(3)	4630(3)
BW = Body Weight (kg)	70	15
AT = Averaging Time (days)		
Noncarcinogenic	~~8760~~ 10950	~~2190~~ 10950
Carcinogenic	25550	25550

(1) For calculation of these numbers, see Appendix B

(2) It is assumed that exposure to indoor dust and outdoor dust occurs 350 days/year It is further assumed that contaminant concentrations in indoor dust equal that in outdoor dust and that the magnitude of dust exposure indoors is equal to dust exposure outdoors

(3) See RAGS, Part B (Publication 9285 7-01B, December, 1991, Interim), page 30, 4 63 x 10^9 m^3/kg = 4630 m^3/mg

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Table A-4

Exposure Parameters and Intake Algorithm
Residential Exposure: Ingestion of Homegrown Fruits and Vegetables

<u>Use only for Metals contamination</u>

$$\text{Intake (mg/kg-day)} = \frac{C \times IR \times FI \times EF \times ED \times CF}{BW \times AT}$$

Parameter	**Adult**	**Child**
C = Chemical concentration in food (mg/kg)[1]	Site-specific	Site-specific
IR = Ingestion Rate (mg/day)	122,000[2]	122,000[2]
FI = Fraction Ingested from contaminant source	0 36[3]	0 36[3]
EF = Exposure Frequency (days/year)	350	350
ED = Exposure Duration (years)	24	6
CF = Conversion Factor (kg/mg)	10^{-6}	10^{-6}
BW = Body Weight (kg)	70	15
AT = Averaging Time (days)		
Noncarcinogenic	~~8760~~ 10950	~~2190~~ 10950
Carcinogenic	25550	25550

(1) Information on uptake into various fruits and vegetables is available in Baes, et al 1984

(2) EPA 1989d, page 2-24, EPA 1991a, page 7, 200000 mg/day is the typical total consumption value for vegetables, 140000 mg/day is the consumption value for fruits, with 40% and 30% being homegrown respectively Therefore a total of 122000 mg/day is used in this table ((200000 mg/day x 0 40) + (140000 mg/day x 0 30) = 122000 mg/day)

(3) EPA 1991a, page 7, the number is the average fraction of consumed vegetables and fruits, prorated by consumption rate, that are homegrown - [(200 x 0 40) + (140 x 0 30)]/340 = 0 36

Table A-5

Exposure Parameters and Intake Algorithm
Residential Exposure: Inhalation of Indoor Air VOCs

<u>Use only at sites with subsurface soil VOC contamination</u>

$$\text{Intake (mg/kg-day)} = \frac{C \times DF \times IR \times ET \times EF \times ED}{BW \times AT}$$

Parameter	**Adult**	**Child**
C = Chemical concentration in soil gas (mg/m^3)	Site-specific[1]	Site-specific[1]
DF = Dilution Factor	0 0017[2]	0 0017[2]
IR = Inhalation Rate (m^3/hour)	0 68[3]	0 66[3]
ET = Exposure Time (hours/day)	22[4]	21[4]
EF = Exposure Frequency (days/year)	350	350
ED = Exposure Duration (years)	24	6
BW = Body Weight (kg)	70	15
AT = Averaging Time (days)		
Noncarcinogenic	~~8760~~ 10950	~~2190~~ 10950
Carcinogenic	25550	25550

(1) Appropriate models for calculating a concentration of VOCs in indoor air from a concentration in soil are under evaluation These will be finalized by July 1, 1994, when this policy is made final Until then, this pathway can not be evaluated and should not be considered in risk evaluations

(2) EPA 1992b, page A-17 This factor assumes that external soil vapor is diluted as it enters the foundation of a building by almost a factor of 600

(3) For calculation of these numbers, see Appendix B

(4) Roy and Courtay, 1991

Table A-6

Exposure Parameters and Intake Algorithm
Construction/Maintenance Worker Exposure: Soil Ingestion

Intake (mg/kg-day) = $\frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$		
Parameter	**Adult**	**Child**
C = Chemical concentration in soil (mg/kg)	Site-specific	NA
IR = Ingestion Rate (mg/day)	480(1)	
EF = Exposure Frequency (days/year)	60(2)	
ED = Exposure Duration (years)	10(2)	
CF = Conversion Factor (kg/mg)	10^{-6}	
BW = Body Weight (kg)	70(3)	
AT = Averaging Time (days)		
Noncarcinogenic	~~600~~(4) 3650	
Carcinogenic	25550	

(1) EPA 1991a, Attachment B

(2) It is assumed that exposure of a construction worker at a facility to surface and subsurface soil occurs 60 days/year It is further assumed that the exposure continues at 60 days/year for 10 years

(3) EPA 1989a, Chapter 6, EPA 1989d

(4) ~~600 days = 10 years X 60 days/year~~ 3650 = 10 years X 265 days/year
25550 days = 70 years x 365 days/year

NA Not Applicable

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Table A-7

Exposure Parameters and Intake Algorithm
Construction/Maintenance Worker Exposure: Dermal Contact with Soil

Intake (mg/kg-day) = $\frac{C \times SA \times AB \times AF \times EF \times ED \times CF}{BW \times AT}$		
Parameter	**Adult**	**Child**
C = Chemical concentration in soil (mg/kg)	Site-specific	NA
SA = Exposed Surface Area of body (cm^2)	4700[(1)]	
AB = Absorption Factor (unitless)	0 5[(2)]	
AF = Adherence Factor (mg/cm^2/event)	1 0	
EF = Exposure Frequency (events/year)	60[(3)]	
ED = Exposure Duration (years)	10[(3)]	
CF = Conversion Factor (kg/mg)	10^{-6}	
BW = Body Weight (kg)	70	
AT = Averaging Time (days)		
Noncarcinogenic	~~600~~ 3650	
Carcinogenic	25550	

(1) For calculation of these numbers, see Appendix B

(2) Absorption is chemical specific Values for some chemicals are available in EPA 1992a In the absence of published data, a value of 0 5 will be used (EPA 1989a, page 6-39)

(3) It is assumed that exposure of a construction worker at a facility to surface and subsurface soil occurs 60 days/year It is further assumed that the exposure continues at 60 days/year for 10 years

NA Not Applicable

Table A-8

Exposure Parameters and Intake Algorithm
Construction/Maintenance Worker Exposure: Inhalation of Soil Particulates

Use only for inorganic Parameters

$$\text{Intake (mg/kg-day)} = \frac{C \times CF \times IR \times ET \times EF \times ED}{PEF \times BW \times AT}$$

Parameter	Adult	Child
C = Chemical concentration in soil (mg/kg)	Site-specific	NA
CF = Conversion Factor (kg/mg)	10^{-6}	
IR = Inhalation Rate (m^3/hour)	0 83(1)	
ET = Exposure Time (hours/day)	8	
EF = Exposure Frequency (days/year)	60	
ED = Exposure Duration (years)	10	
PEF = Particulate Emission Factor (m^3/mg)	4630(2)	
BW = Body Weight (kg)	70	
AT = Averaging Time (days)		
Noncarcinogenic	3650	
Carcinogenic	25550	

(1) For calculation of these numbers, see Appendix B

(2) See Table A-3

NA Not Applicable

Table A-9

Exposure Parameters and Intake Algorithm
Construction/Maintenance Worker Exposure: Inhalation of Indoor Air VOCs

Use only at sites with subsurface soil VOC contamination

$$\text{Intake (mg/kg-day)} = \frac{C \times DF \times IR \times ET \times EF \times ED}{BW \times AT}$$

Parameter	Adult	Child
C = Chemical concentration in soil gas (mg/m^3)	Site-specific[1]	NA
DF = Dilution Factor	0 0017[2]	
IR = Inhalation Rate (m^3/hour)	0 63[3]	
ET = Exposure Time (hours/day)	8	
EF = Exposure Frequency (days/year)	60	
ED = Exposure Duration (years)	10	
BW = Body Weight (kg)	70	
AT = Averaging Time (days)		
Noncarcinogenic	3650	
Carcinogenic	25550	

(1) Appropriate models for calculating a concentration of VOCs in indoor air from a concentration in soil are under evaluation These will be finalized by July 1, 1994, when this policy is made final Until then, this pathway can not be evaluated and should not be considered in risk evaluations

(2) See Table A-5

(3) For calculation of these numbers, see Appendix B

NA Not Applicable

Table A-10

Exposure Quantification - Intake Calculation
Example Spreadsheet

						Contaminant
Max Concentration in SWMU	**A**		**B**		**C**	
Soil Modeled particulates to air from soil VOCs to indoor air						
Pathway	NC	C	NC	C	NC	C
1(1) - child intake (mg/kg-day) adult intake (mg/kg-day) TOTAL INTAKE						
2 - child intake adult intake TOTAL INTAKE						
3 - child intake adult intake TOTAL INTAKE						
4 - child intake adult intake TOTAL INTAKE						
5 - child intake adult intake TOTAL INTAKE						
6(2) - child intake adult intake TOTAL INTAKE						
7(2) - child intake adult intake TOTAL INTAKE						
8(2) - child intake adult intake TOTAL INTAKE						
9(2) - child intake adult intake TOTAL INTAKE						

(1) Table A-1 covers Pathway 1, Table A-2 covers Pathway 2, etc

(2) Use worker pathways only when applicable

NC, C Noncarcinogenic or Carcinogenic intake for given contaminant

Table A-11

Residential Risk Characterization - Risk Calculation
Example Spreadsheet - Carcinogens

	Contaminant - Carcinogen						
	A	**B**	**C**	**D**	**E**	**F**	**G**
Pathway							
1[1] - Total Intake (mg/kg-day) X Slope factor (mg/kg-day) ^{1} = RISK	______	______	______	______	______	______	______
2 - Total Intake (mg/kg-day) X Slope factor (mg/kg-day) ^{1} = RISK	______	______	______	______	______	______	______
3 - Total Intake (mg/kg-day) X Slope factor (mg/kg-day) ^{1} = RISK	______	______	______	______	______	______	______
4 - Total Intake (mg/kg-day) X Slope factor (mg/kg-day) ^{1} = RISK	______	______	______	______	______	______	______
5 - Total Intake (mg/kg-day) X Slope factor (mg/kg-day) ^{1} = RISK	______	______	______	______	______	______	______
Total Residential Contaminant-Specific Risk							
TOTAL RESIDENTIAL RISK [2]							

(1) Table A-1 covers Pathway 1, Table A-2 covers Pathway 2, etc

(2) Total Risk = Sum of the Contaminant Specific Risks

Table A-12

Construction Worker Risk Characterization - Risk Calculation Example Spreadsheet - Carcinogens

	Contaminant - Carcinogen						
	A	**B**	**C**	**D**	**E**	**F**	**G**
Pathway							
6[(1)(2)] - Total Intake (mg/kg-day) X Slope factor (mg/kg-day)^{1} = RISK	______	______	______	______	______	______	______
7 - Total Intake (mg/kg-day) X Slope factor (mg/kg-day)^{1} = RISK	______	______	______	______	______	______	______
8 - Total Intake (mg/kg-day) X Slope factor (mg/kg-day)^{1} = RISK	______	______	______	______	______	______	______
9 - Total Intake (mg/kg-day) X Slope factor (mg/kg-day)^{1} = RISK	______	______	______	______	______	______	______
Total Construction Worker Contaminant-Specific Risk							
TOTAL WORKER RISK [(3)]							

(1) Table A-6 covers Pathway 6, Table A-7 covers Pathway 7, etc

(2) Use Construction Worker pathways only if applicable

(3) Total Risk = Sum of the Contaminant Specific Risks

Table A-13

Residential Risk Characterization - Risk Calculation
Example Spreadsheet - Noncarcinogens

	Contaminant - Noncarcinogen						
	A	**B**	**C**	**D**	**E**	**F**	**G**
Pathway							
1[1] - Total Intake (mg/kg-day) / RfD (mg/kg-day) = Hazard Quotient (HQ)	______	______	______	______	______	______	______
2 - Total Intake (mg/kg-day) / RfD (mg/kg-day) = HQ	______	______	______	______	______	______	______
3 - Total Intake (mg/kg-day) / RfD (mg/kg-day) = HQ	______	______	______	______	______	______	______
4 - Total Intake (mg/kg-day) / RfD (mg/kg-day) = HQ	______	______	______	______	______	______	______
5 - Total Intake (mg/kg-day) / RfD (mg/kg-day) = HQ	______	______	______	______	______	______	______
Total Residential Contaminant-Specific HQ							
TOTAL RESIDENTIAL Hazard Quotient [3]							

(1) Table A-1 covers Pathway 1, Table A-2 covers Pathway 2, etc

(2) Total HQ = Sum of the Contaminant Specific HQs

Table A-14

Construction Worker Risk Characterization - Risk Calculation
Example Spreadsheet - Noncarcinogens

	Contaminant - Noncarcinogen						
	A	B	C	D	E	F	G
Pathway							
6[1][2] - Total Intake (mg/kg-day) / RfD (mg/kg-day) = Hazard Quotient (HQ)	_____	_____	_____	_____	_____	_____	_____
7 - Total Intake (mg/kg-day) / RfD (mg/kg-day) = HQ	_____	_____	_____	_____	_____	_____	_____
8 - Total Intake (mg/kg-day) / RfD (mg/kg-day) = HQ	_____	_____	_____	_____	_____	_____	_____
9 - Total Intake (mg/kg-day) / RfD (mg/kg-day) = HQ	_____	_____	_____	_____	_____	_____	_____
Total Construction Worker Contaminant-Specific HQ							
TOTAL Construction Worker Hazard Quotient[3]							

(1) Table A-1 covers Pathway 1, Table A-2 covers Pathway 2, etc

(2) Use Construction Worker pathways only if applicable

(3) Total HQ = Sum of the Contaminant Specific HQs

APPENDIX B Exposure Parameter Background

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EXPOSURE PARAMETER EXPLANATION

Dermal Contact With Soil

Surface Area - For children, it is assumed that head, hands, arms, legs, and feet are the areas of the body most likely to contact contaminated soil or indoor dust To quantify this, first an average total surface area for children is calculated (50th %tile, male and female average, ages 2-6, EPA 1989d, pages 4-30, 4-31) This average total surface area is multiplied by the sum of the percentages that each body part represents (EPA 1989d, pages 4-12, 4-13)

Children

$$\text{Total body SA}_{(\text{ave-boys})} = \frac{603 + 664 + 731 + 793 + 866}{5} = 0\ 731\ m^2$$

$$\text{Total body SA}_{(\text{ave-girls})} = \frac{579 + 649 + 706 + 779 + 843}{5} = 0\ 711\ m^2$$

$$\text{Total body SA}_{(\text{ave})} = \frac{731 + 711}{2} = 0\ 721\ m^2$$

$$\begin{aligned} SA &= (\%SAhead + \%SAhands + \%SAarms + \%SAlegs + \%SAfeet) \times (\text{tot } SA_{\text{ave}}) \\ &= [(\ 15 +\ 05 +\ 13 +\ 25 +\ 06)(\ 721)] \\ &= 0\ 4600\ m^2 \text{ (see Table A-2)} \end{aligned}$$

Adults

For residential adults, it is assumed that head, hands, arms, and lower legs are most likely to contact contaminated soil and indoor dust Therefore, an average surface area is calculated using the average surface area (50th %tile) for both males and females of each of these body areas (EPA 1989d, pages 4-28, 4-29)

$$\begin{aligned} SA &= (SAhead + SAhands + SAarms + SAlegs) \\ &= (\ 12 +\ 09 +\ 26 +\ 24) \\ &= 0\ 7100\ m^2 \text{ (see Table A-2)} \end{aligned}$$

For the construction worker exposure calculation, it is assumed that only head hands and arms are likely to contact contaminated soil Therefore, an average surface area is calculated using the average surface area (50th %tile for both males and females of each of these body areas (EPA 1989d, pages 4-28 and 4-29)

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$SA = (SAhead + SAhands + SAarms)$
$= (12 + 09 + 26)$
$= 4700\ m^2$ (see Table A-7)

50th %tile surface area values were used so as to agree with the 50th %tile body weights because of the strong correlation between SA and Body Weight

Absorption Factor - The dermal bioavailability of a given soil contaminant can vary between 0 05 and 0 5 In the absence of compound-specific published data, a value of 0 5 will be used for ABS (EPA 1989a, page 6-39)

Inhalation of Soil Particulates

Inhalation Rate - Inhalation rates, for both children and adults, must consider outdoor and indoor values From Roy and Courtay, 1991, time spent outdoors for children and adults is assumed to be 3 hours/day Therefore, time spent indoors is 21 hours/day Further breakdown of the hours spent indoors and outdoors with respect to activity level, and the inhalation rates associated with each activity, can be found in EPA 1989d The calculation of average adult and child inhalation rate becomes

Children - Indoors

Activity	% of time	activity inhltn rate	hours indoors	m^3
resting	48	0 4 m^3/hr	21	4 03
light	48	0 8	21	8 06
moderate	3	2 0	21	1 26
heavy	1	2 4	21	0 50
				13 85

Children - Outdoors

Activity	% of time	activity inhltn rate	hours outdoorsm^3	
resting	28	0 4 m^3/hr	3	0 34
light	28	0 8	3	0 67
moderate	37	2 0	3	2 22
heavy	7	2 4	3	0 50
				3 73

Total

13 85 + 3 73 = 17 58 m^3 17 58 m^3 /24 hours = 0 73 m^3/hr (see Table A-3)

13 85 m^3/21 hours = 0 66 m^3/hr (see Table A-5)

Adults

For adults, more standard values are available EPA 1991a states a reasonable upper bound for adults, combining indoor and outdoor time, is 20 m^3/day This converts to 0 83 m^3/hour and appears in Table A-3 EPA 1991a further states that 15 m^3/day is a reasonable upper bound for indoor activities This converts to 0 68 m^3/hour for the 22 hours spent indoors and appears on Table A-5

APPENDIX C Bibliography

BIBLIOGRAPHY:

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EPA 1989a Risk Assessment Guidance for Superfund (RAGS), Volume I Human Health Evaluation Manual

EPA 1989b Interim Final Guidance for Soil Ingestion Rates, Office of Solid Waste and Emergency Response (OSWER) Directive 9850 4

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EPA 1991a Supplemental Guidance Standard Default Exposure Factors, OSWER Directive 9285 6-03

EPA 1991b Interim Guidance for Dermal Exposure Assessments (Draft), OHEA-E-367, March, 1991

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EPA 1992b Air/Superfund National Technical Guidance Study Series - Assessing Potential Indoor Air Impacts for Superfund Sites, EPA 451/R-92-002, September, 1992

Roy and Courtay, 1991 Daily Activities and Breathing Parameters for Use in Respiratory Tract Dosimetry, Commissariat a L'Energie Atomique, IPSN/DPS/SEAPS, Radiation Protection Dosimetry Vol 35, No 3, pp 179-186, 1991

TO Hazardous Waste Control Program

FROM Joe Schieffelin

RE Errors in "Interim Final Policy and Guidance on Risk Assessments for Corrective Action at RCRA Facilities"

As a followup to yesterday's E-Mail message, I thought it would be useful to summarize in hardcopy the errors we have found to date in the above policy Please feel free to share this with facilities you are working with This includes one additional error (bringing the total to three) that I forgot to mention yesterday Sorry for the inconvenience

Error 1: Please delete the second paragraph under the <u>Carcinogens</u> heading on page 10 that begins with the sentence "When possible, organ-specific carcinogenic risk should be evaluated " Organspecific carcinogenicity cannot be evaluated because chemical slope factors are not organ-specific There is not enough information currently to explicitly assume that, even when a chemical is known to cause liver cancer (for example) , it will not cause other types of cancer as well The mechanisms of carcinogenic genesis are not understood well enough to make organ-specific predictions Therefore, implementation of the policy should include a summation of cancer risk for all chemicals at site in each pathway and a sum of the pathway risks into a total risk (RAGS, Chapter 8), as outlined in the previous paragraph on page 10

Sufficient information does exist, however, to evaluate noncarcinogenic organ-specific toxicity Therefore, no change is necessary from the policy, as it is currently written, for noncarcinogens (RAGS, Chapter 8)

Error 2: At the bottom of Tables A-1 through A-5, please replace both of the values listed for Averaging Time/Noncarcinogenic (8760 days for adults and 2190 days for children) with the sum of those two numbers, 10950 days This corrects the time-weighted averaging that needs to be done to evaluate these pathways

Error 3: The second paragraph from the bottom of page ~~11~~ 10 states that Appendix C includes case studies of the application of this policy and guidance This is not the case In an effort to accelerate the release of this policy, we have not yet developed these examples However, before the final version of this policy is released in July or August, 1994, we hope to develop such examples As such, Appendix C is now the bibliography (which is correctly indicated on the Table of Contents)